In [1]:

```
# importing various libraries which are used
import pandas as pd
import matplotlib.pyplot as plt
import seaborn as sns
from sklearn.linear_model import LinearRegression
from sklearn.model_selection import train_test_split
from sklearn import preprocessing as p
from scipy.stats import f
from sklearn.metrics import mean_squared_error, mean_absolute_error ,r2_score
```

In [2]:

```
# taking the csv file as input to create the model
file=input("csv file_name : ")
```

```
csv file_name : 527.csv
```

In [3]:

```
# creating a pandas dataframe using the values obtained in the csv
df=pd.read_csv(file)
```

In [4]:

```
# printing the head of the data frame to get the gist of the values
print("\n data frame head :- \n",df.head())
```

```
 data frame head :-
        time  cpu-cycles  instructions  l1d.replacement  icache_64b.if
tag_miss  \
0  0.100124   391442619     838033474          4672892
1938487
1  0.200384   458722014     824494445          8012511
724536
2  0.300599   458090406     968199504         14803958
2033882
3  0.400817   458921423    2440757647         36134878
114897
4  0.501015   459421503    2665878574         36380102
13650

   l2_rqsts.all_demand_miss  longest_lat_cache.miss  \
0                   4101309                 3950947
1                   4206029                 4924493
2                   3543501                 4925686
3                   3041511                  980581
4                     16107                   48206

   br_inst_retired.all_branches  frontend_retired.itlb_miss  \
0                     127387471                        7095
1                     166774863                        1057
2                     142838756                        6231
3                     567382444                        1318
4                     739118039                          24

   itlb_misses.walk_completed  dtlb_load_misses.walk_completed  \
0                       12294                            14745
1                        5446                            21253
2                       12585                            31901
3                        1610                             2881
4                          51                               15

   dtlb_store_misses.walk_completed  branch-misses
0                            529016         307806
1                            859907         229381
2                            345347         190192
3                            103308          96542
4                               100          43623
```

In [5]:

```
# creating a new col in our data frame which consists of the CPI per tuple
df[['CPI']]=df[['cpu-cycles']].div(df['instructions'], axis=0)
print(df)
```

```
            time  cpu-cycles  instructions  l1d.replacement  \
0       0.100124   391442619     838033474          4672892
1       0.200384   458722014     824494445          8012511
2       0.300599   458090406     968199504         14803958
3       0.400817   458921423    2440757647         36134878
4       0.501015   459421503    2665878574         36380102
...          ...         ...           ...              ...
1782  178.703398   459076862    1106282014         25237706
1783  178.803633   459296289    1105537370         24946579
1784  178.903849   459185132    1095741849         24587823
1785  179.004076   459332212    1097159966         24346215
1786  179.052989   223728647     513519272          6688965

      icache_64b.iftag_miss  l2_rqsts.all_demand_miss  longest_lat_cac
he.miss  \
0                   1938487                   4101309
3950947
1                    724536                   4206029
4924493
2                   2033882                   3543501
4925686
3                    114897                   3041511
980581
4                     13650                     16107
48206
...                     ...                       ...
...
1782                1898551                   6360103
556986
1783                1890447                   6229820
531121
1784                1864575                   6097333
538498
1785                1864355                   6064201
490976
1786                  86790                   1145462
1758481

      br_inst_retired.all_branches  frontend_retired.itlb_miss  \
0                        127387471                        7095
1                        166774863                        1057
2                        142838756                        6231
3                        567382444                        1318
4                        739118039                          24
...                            ...                         ...
1782                     150097002                       20465
1783                     149316738                       21078
1784                     147927142                       20395
1785                     147858671                       20612
1786                      76457207                        4185

      itlb_misses.walk_completed  dtlb_load_misses.walk_completed  \
0                          12294                            14745
1                           5446                            21253
2                          12585                            31901
3                           1610                             2881
4                             51                               15
...                          ...                              ...
1782                       50919                            78772
1783                       53040                            77870
1784                       53004                            79081
```

```
1785                          50386                                75443
1786                          11000                                25408

      dtlb_store_misses.walk_completed  branch-misses       CPI
0                               529016         307806  0.467097
1                               859907         229381  0.556368
2                               345347         190192  0.473136
3                               103308          96542  0.188024
4                                  100          43623  0.172334
...                                ...            ...       ...
1782                             26938        1657711  0.414973
1783                             26392        1711892  0.415451
1784                             26289        1803251  0.419063
1785                             26440        1886521  0.418656
1786                             32813         543249  0.435677

[1787 rows x 14 columns]
```

In [6]:

```
# dividing all the values by instruction so that we get values in each coloumn per i
df[['l1d.replacement','icache_64b.iftag_miss','l2_rqsts.all_demand_miss','longest_la
print(df)
```

```
            time  cpu-cycles  instructions  l1d.replacement  \
0       0.100124   391442619     838033474         0.005576
1       0.200384   458722014     824494445         0.009718
2       0.300599   458090406     968199504         0.015290
3       0.400817   458921423    2440757647         0.014805
4       0.501015   459421503    2665878574         0.013647
...          ...         ...           ...              ...
1782  178.703398   459076862    1106282014         0.022813
1783  178.803633   459296289    1105537370         0.022565
1784  178.903849   459185132    1095741849         0.022439
1785  179.004076   459332212    1097159966         0.022190
1786  179.052989   223728647     513519272         0.013026

      icache_64b.iftag_miss  l2_rqsts.all_demand_miss  longest_lat_cac
he.miss  \
0                  0.002313                  0.004894
0.004715
1                  0.000879                  0.005101
0.005973
2                  0.002101                  0.003660
0.005087
3                  0.000047                  0.001246
0.000402
4                  0.000005                  0.000006
0.000018
...                     ...                       ...
...
1782               0.001716                  0.005749
0.000503
1783               0.001710                  0.005635
0.000480
1784               0.001702                  0.005565
0.000491
1785               0.001699                  0.005527
0.000447
1786               0.000169                  0.002231
0.003424

      br_inst_retired.all_branches  frontend_retired.itlb_miss  \
0                         0.152008                8.466249e-06
1                         0.202275                1.281998e-06
2                         0.147530                6.435657e-06
3                         0.232462                5.399963e-07
4                         0.277251                9.002661e-09
...                            ...                         ...
1782                      0.135677                1.849890e-05
1783                      0.135063                1.906584e-05
1784                      0.135002                1.861296e-05
1785                      0.134765                1.878669e-05
1786                      0.148889                8.149645e-06

      itlb_misses.walk_completed  dtlb_load_misses.walk_completed  \
0                   1.467006e-05                     1.759476e-05
1                   6.605260e-06                     2.577701e-05
2                   1.299835e-05                     3.294879e-05
3                   6.596312e-07                     1.180371e-06
4                   1.913065e-08                     5.626663e-09
...                          ...                              ...
1782                4.602714e-05                     7.120427e-05
1783                4.797667e-05                     7.043633e-05
1784                4.837271e-05                     7.217120e-05
```

```
1785                 4.592402e-05                          6.876208e-05
1786                 2.142081e-05                          4.947818e-05

      dtlb_store_misses.walk_completed  branch-misses       CPI
0                           6.312588e-04       0.000367  0.467097
1                           1.042951e-03       0.000278  0.556368
2                           3.566899e-04       0.000196  0.473136
3                           4.232620e-05       0.000040  0.188024
4                           3.751109e-08       0.000016  0.172334
...                                  ...            ...       ...
1782                        2.435003e-05       0.001498  0.414973
1783                        2.387255e-05       0.001548  0.415451
1784                        2.399196e-05       0.001646  0.419063
1785                        2.409858e-05       0.001719  0.418656
1786                        6.389828e-05       0.001058  0.435677

[1787 rows x 14 columns]
```

In [7]:

```
# droping values such as time , instructions , cpu-cycles and br_inst_retired.all_br
df= df.drop(['time'], axis=1)
df= df.drop(['instructions'], axis=1)
df= df.drop(['cpu-cycles'], axis=1)
df= df.drop(['br_inst_retired.all_branches'], axis=1)
```

In [8]:

```
# assigning y as the CPI and then droping it from the dataframe
y=df['CPI']
df= df.drop(['CPI'], axis=1)
print("y values :- \n",y)
```

```
y values :-
 0       0.467097
1       0.556368
2       0.473136
3       0.188024
4       0.172334
          ...
1782    0.414973
1783    0.415451
1784    0.419063
1785    0.418656
1786    0.435677
Name: CPI, Length: 1787, dtype: float64
```

In [9]:

```
# assigning x as the dataframe
x=df
print("x values :- \n",x)
```

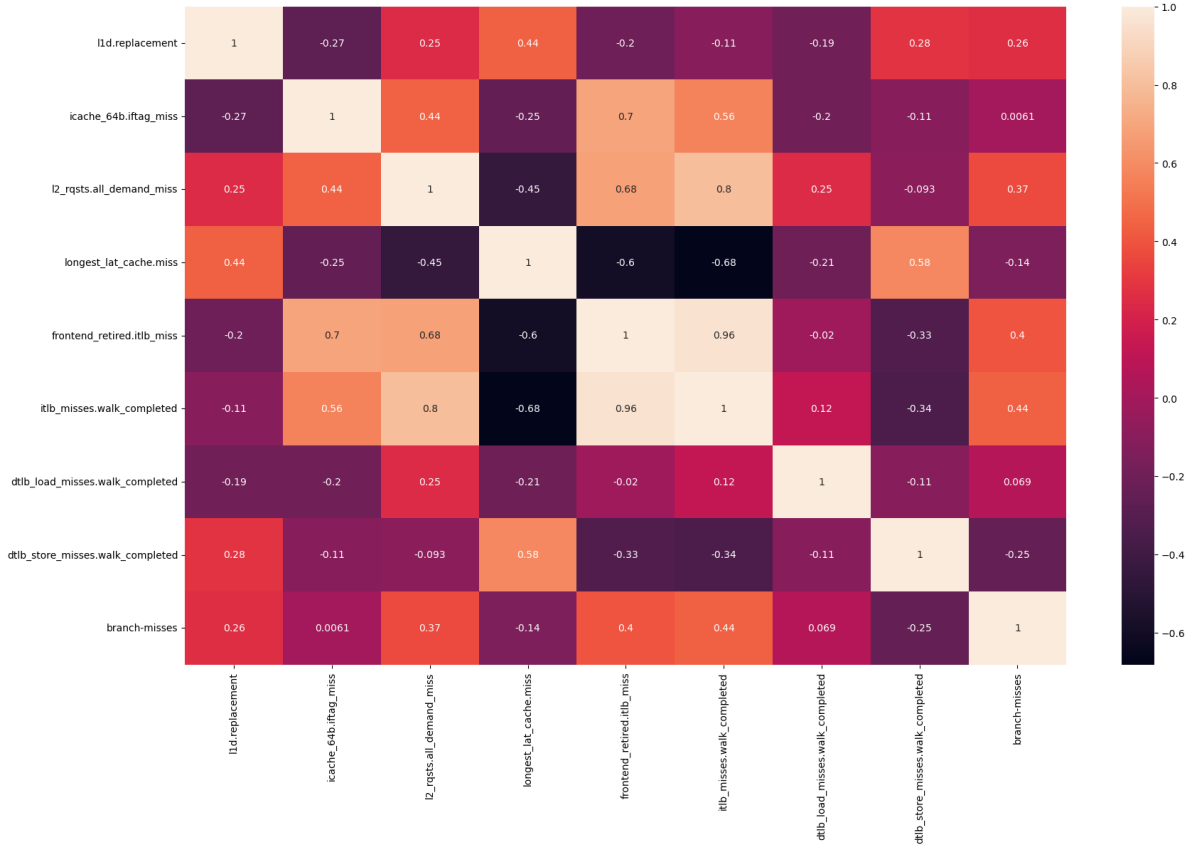
```
x values :-
       l1d.replacement  icache_64b.iftag_miss  l2_rqsts.all_demand_mis
s  \
0             0.005576               0.002313                  0.004894
1             0.009718               0.000879                  0.005101
2             0.015290               0.002101                  0.003660
3             0.014805               0.000047                  0.001246
4             0.013647               0.000005                  0.000006
...                ...                    ...                       ...
1782          0.022813               0.001716                  0.005749
1783          0.022565               0.001710                  0.005635
1784          0.022439               0.001702                  0.005565
1785          0.022190               0.001699                  0.005527
1786          0.013026               0.000169                  0.002231

      longest_lat_cache.miss  frontend_retired.itlb_miss  \
0                   0.004715                8.466249e-06
1                   0.005973                1.281998e-06
2                   0.005087                6.435657e-06
3                   0.000402                5.399963e-07
4                   0.000018                9.002661e-09
...                      ...                         ...
1782                0.000503                1.849890e-05
1783                0.000480                1.906584e-05
1784                0.000491                1.861296e-05
1785                0.000447                1.878669e-05
1786                0.003424                8.149645e-06

      itlb_misses.walk_completed  dtlb_load_misses.walk_completed  \
0                   1.467006e-05                     1.759476e-05
1                   6.605260e-06                     2.577701e-05
2                   1.299835e-05                     3.294879e-05
3                   6.596312e-07                     1.180371e-06
4                   1.913065e-08                     5.626663e-09
...                          ...                              ...
1782                4.602714e-05                     7.120427e-05
1783                4.797667e-05                     7.043633e-05
1784                4.837271e-05                     7.217120e-05
1785                4.592402e-05                     6.876208e-05
1786                2.142081e-05                     4.947818e-05

      dtlb_store_misses.walk_completed  branch-misses
0                         6.312588e-04       0.000367
1                         1.042951e-03       0.000278
2                         3.566899e-04       0.000196
3                         4.232620e-05       0.000040
4                         3.751109e-08       0.000016
...                                ...            ...
1782                      2.435003e-05       0.001498
1783                      2.387255e-05       0.001548
1784                      2.399196e-05       0.001646
1785                      2.409858e-05       0.001719
1786                      6.389828e-05       0.001058

[1787 rows x 9 columns]
```

In [10]:

```
# creating a heatmap of the correlation matrix
fig,axis = plt.subplots(figsize = (20,12))
sns.heatmap(x.corr(),annot=True)
```

Out[10]:

```
<AxesSubplot:>
```



In [11]:

```
# dividing the data set into test and train set in a 20:80 ration with a random stat
# the model trains on a particular set of values on every execution
X_train, X_test, y_train, y_test = train_test_split(
    x, y, test_size=.20,random_state=55)
```

In [12]:

```
# using MinMax Scaler to scale the data within the given range of 0 to 1 such that
#shape of the original distribution is same after transformation
mms = p.MinMaxScaler()
X_train = mms.fit_transform(X_train)
X_test = mms.transform(X_test)
```

In [13]:

```
print("X_train :-\n",X_train)
```

```
X_train :-
 [[0.79314573 0.0050912  0.14600265 ... 0.03258717 0.06711874 0.292052
25]
 [0.09406963 0.07198746 0.20338952 ... 0.23342334 0.01151723 0.1827653
3]
 [0.58085627 0.26508165 0.7363117  ... 0.33574908 0.0223402  0.5101172
1]
 ...
 [0.5896975  0.25885378 0.75880007 ... 0.2276213  0.01707649 0.5049552
2]
 [0.53056337 0.00699969 0.262387   ... 0.24328858 0.02494733 0.7319574
9]
 [0.58800353 0.2532273  0.74706091 ... 0.34812232 0.02175311 0.5023423
7]]
```

In [14]:

```
# mean of all the columns of the training set
df2 = X_train.mean(axis=0)
print(df2)
```

```
[0.43088568 0.23202107 0.43205713 0.24074808 0.39568289 0.44692034
 0.19674435 0.02998797 0.41483899]
```

In [15]:

```
# creating a linear regression model using sklearn.linear_model
model = LinearRegression(positive=True)
model.fit(X_train,y_train)
```

Out[15]:

```
LinearRegression(positive=True)
```

In [16]:

```
# finding the coefficients given by our model
c=model.coef_
print("\nCoefficients :- \n",c)
```

```
Coefficients :-
 [0.         0.09134632 0.         0.         0.03808315 0.
 0.         0.07557319 0.        ]
```

In [17]:

```
# model intercept i.e. the " Base CPI "
i=model.intercept_
print("\nBase CPI : ",i)
```

```
Base CPI :  0.38959324688623
```

In [18]:

```
# making the predictions using our model on the test set
predictions = model.predict(X_test)
```

In [19]:

```
# Actual CPI
ACPI = y_test.mean()
print("\n Actual CPI : ",ACPI)
```

```
 Actual CPI :  0.42670313145756683
```

In [20]:

```
# Predicted CPI
PCPI = predictions.mean()
print("\n Predicted CPI : ",PCPI)
```

```
 Predicted CPI :  0.42824986157706524
```

In [21]:

```
# Finding out RMSE , R^2 , adjusted R^2 using our predictions and test set
MSE = mean_squared_error(y_test, predictions)
rint("\n RMSE : ",RMSE)

2 = r2_score(y_test, predictions)
rint("\n R^2 : ",r2_score(y_test, predictions))

djusted_r2 = 1 - ( 1-model.score(X_test,y_test) ) * ( len(y_test) - 1 ) / ( len(y_tes
rint("\n adjusted R^2 : ",adjusted_r2)
```

```
 RMSE :  0.0007099115294998692

 R^2 :  0.4930744890263563

 adjusted R^2 :  0.4799643465011758
```

In [22]:

```
# finding absolute error and accuracy on test set
err = mean_absolute_error(y_test, predictions)
print ( "\n Test error is :" , err *100 , "% " )
print ( "\n Test Accuracy is :" , (1- err) *100 , "%" )
```

```
 Test error is : 2.463222168538672 %

 Test Accuracy is : 97.53677783146134 %
```

In [23]:

```
# F-statistic value which should be > 2.5 and p-value which should be < 0.05
F = (R2/(1-R2))*((X_test.shape[0]-1-X_test.shape[1])/X_test.shape[1])
print("\n F-statistic : ",F)

p = 1-f.cdf(F,X_test.shape[1],(X_test.shape[0]-1-X_test.shape[1]))
print("\n p-value : ",p)
```

```
 F-statistic :  37.610154739303255

 p-value :  1.1102230246251565e-16
```

In [24]:

```
#no of coefficients
X_test.shape[1]
```

Out[24]:

```
9
```

In [25]:

```
# no of tuples in the test set
X_test.shape[0]
```

Out[25]:

```
358
```

In [26]:

```
# finding the residual for our test set
residuals = y_test - predictions
print("\n Residual :- \n ",residuals)
```

```
 Residual :-
  608     0.000956
799     0.009880
494     0.032234
1267    0.026791
911    -0.039996
          ...
659    -0.019675
725    -0.021207
1773   -0.023418
658    -0.020445
535     0.033018
Name: CPI, Length: 358, dtype: float64
```

In [27]:

```
# residual graph
data = {
    'predicted': [i for i in predictions],
    'residuals': [i for i in residuals]
}

dfr = pd.DataFrame(data)
sns.scatterplot(data=dfr, x="predicted", y="residuals")
```

Out[27]:

```
<AxesSubplot:xlabel='predicted', ylabel='residuals'>
```